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DIGESTION EXPERIMENTS WITH POULTRY.

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BULLETIN No. 184

DIGESTION EXPERIMENTS WITH POULTRY.

J. M. Bartlett.

The digestibility of American feeding stuffs has been quite extensively studied in this country with ruminants, horses and hogs but as yet only a few experiments have been made with poultry. It is obvious that such studies are desirable on account of their practical importance and the growing demand for information in regard to the care and management of fowls which has come with the great increase in the poultry industry in recent years.

A few years ago the great bulk of the eggs and poultry which supplied our markets was produced by farmers, who let their hens run at large for the greater part of the year, picking up their living in the fields and pastures, supplimented perhaps by a feed of corn at night. But today when great plants are established, carrying thousands of birds, only the most careful and scientific methods of handling and feeding will make the business profitable. Several of the Experiment Stations have considered questions of poultry nutrition and much valuable information has been gained through feeding experiments for growth, egg production, etc., but the absence of definite standards and coefficients of digestibility of different foods for this class of animal has been a serious drawback to the best work. The abundant data available for other classes of farm animals might possibly be used to good advantage with poultry but the structure of the alimentary canal of birds is quite different from that of herbiverous animals, consequently the digestive capacity may be different.

The fact that the digested and undigested portions of the food are excreted together makes a serious obstacle in performing experiments with birds and greatly increases the amount of analytical work to be done. This probably in part accounts for the small amount of work that has been undertaken in this line. Another difficulty encountered is that fowls are less adaptable to general conditions of digestion experiments than other farm animals, owing to their activity and liability to depression of the normal metabolic processes that might result from being confined in cages without exercise. With all these obstacles in the way it is not surprising that but little digestion work with poultry has been undertaken. The only Experiment Station which has thus far published any results of this nature is the Oklahoma Station, Bulletin 46 by Fields and Ford. Four years later, in 1904, Bulletin No. 56, Bureau of Animal Industry, United States Department of Agriculture, by Dr. E. W. Brown, appeared giving the results of some experiments and a very complete review of the literature on the subject. According to Doctor Brown's review foreign investigators have given much more attention to this class of work than Americans. Two of these investigators, Lehmann and Paraschtschuk, employed an ingenious method of collecting the urine and feces separately by means of an artificial anus established in the body walls. This was brought about by means of an operation, cutting the intestine at a point just back of where the urine emptied into it, and bringing the end out to the body walls. The feces and urin were then collected separately in rubber bags. This method was considered in our work, and Dr. Raymond Pearl of the Biological Department of this Station operated on birds for the purpose. After a few trials a capon, No. 908, was very successfully operated on and made a good recovery but soon after being put on the experimental ration, which was at that time 7 parts corn meal to one part of beef scrap, his bowels became inactive and the feces had to be washed out at each collection. An experiment of several days duration was obtained, however, and is given in the tables, the feces number being 4470. The results compare quite favorably with the others obtained by the chemical separatory method, but the bird could not have been considered in normal condition. After a time the walls of the intestine became weakened and rupture followed. As it did not seem possible that a bird under such abnormal physiological conditions could normally digest its food, further work by this method was abandoned and a method for collecting the feces under natural conditions taken up.

It was fully realized that a chance of considerable error might be introduced in any method that involved a chemical separation of the feces from the urine, but it was not thought practicable to prepare the number of birds by operation for artificial anus necessary to make all the experiments that were desirable even if it could be considered a more accurate procedure.

In the pages which follow an account of the experiments as carried out are given in detail. The composition of the foods and feces are given in Table No. 1. The weight of food and feces together with other data is shown in Table 2. The coefficients found for each feed and bird are given in Table 3. The average coefficients for each feed and mixture are given in Table 4. Table 5 contains the average coefficients of all feeding experiments available to the writer at the present time.

For the success of the experiments much credit is due to Mr. A. C. Whittier and Mr. J. F. Merrill, assistant chemists at the Station when the experiments were going on, who took the greater part of the care of the birds and performed all the analyses except most of the uric acid determinations which were made by the writer.

METHOD OF CONDUCTING THE EXPERIMENTS.

The first experiments undertaken were with year-old hens and were conducted principally to gain information as to the best methods to follow in the succeeding experiments. The work with the female birds was not very satisfactory. They were nervous, uneasy, and many of the experiments undertaken were not carried through on account of the bird getting out of condition. Only a few months during the winter could be given to the work, so but few experiments were performed in these preliminary trials.

For the next season it was planned to have enough capons provided to use for all the experiments but owing to adverse circumstances only about half the number required were obtained, and to fill the deficiency cocks were used. These proved more satisfactory than the hens but were not so quiet and docile as the capons which seem to possess but one idea and that is to eat. For the next season an ample supply of capons was secured for all of the work.

For the accommodation of the birds two convenient rooms were provided, one being fitted with perches in the usual manner where they were kept during the resting periods and the other was furnished with tables on which the cages were kept. The cages in which the birds were confined during the experiment were made of boards for sides, top and bottom, with slats for the back and front. The bottoms were made tight, of matched lumber with base board across the slats to prevent anything being thrown out. The size of the cages was about two feet each way. For feeding and drinking dishes two pint dippers with handles were used for each cage. To hold the dipper in position the handle was passed through a slot in the side of the cage about 8 inches from the bottom and was held in place by a flat wedge outside. These dishes worked very satisfactorily and it was very seldom that any food was spilled from them. The time of the experiments was 12 to 14 days, being divided into two periods, a preliminary period of 5 to 7 days, when the amount the bird would eat was determined and the alimentary canal freed from other food, and a collection period, when the bags were put on and the feces collected. Clean shavings free from any material the birds would eat, were put in the bottom of the cages for the preliminary period, but during the collection period the bottom was kept clean in order to detect any loss of food or feces. No records of the weight of water drank was kept as it was known that the birds every time they dip their bills spill quite a portion of what they take up, therefore it would be impossible to tell how much was swallowed. A liberal amount of grit was supplied them at all times.

The feeding was done regularly at fixed hours morning and evening, and the feces collected at the same time, put in glass jars, and kept covered with alcohol to prevent fermentation. At the end of the collection period the feces were taken to the laboratory, the alcohol evaporated on the steam bath, then dried at 60 degrees C. to air dry condition.

APPARATUS FOR COLLECTING THE FECES.

Fowls are very sensitive and object seriously to any attachments, that interfere with their freedom of motion. The hens used were much more annoyed than the capons which, after a few vigorous efforts to free themselves, would calm down and submit quietly. The various devices used by other experimentors were studied and from suggestions gained thereby the following form which is shown in the cut on page 324 was devised and adopted. It was made of a rectangular piece of pure gum sheet rubber of sufficient size to make a tube 8 inches long and 3 inches in diameter. The edges were firmly cemented together and a ring was cemented to the top at an angle of about 30 degrees to keep the opening sufficiently distended and hold the bag in place. The lower end was closed by means of a screw clamp which could be readily taken off and allow the feces to be removed without removing the apparatus from the bird. It was held in place by 4 pieces of tape attached to the ring, the two upper pieces were carried up over the bird's back and joined just in front of his tail, then the ends were carried forward, passed under and around the wings and tied back of the neck. The two lower pieces were carried under the body, brought up in front of the wings and tied with the others back of the neck. Arranged in this way very little difficulty was experienced in keeping the bags in place and after a few hours wearing the birds appeared to be troubled very little by them. It was necessary, however, to use care in adjusting the straps; if drawn too tightly they were liable to chafe and if too loose the bag would not stay in place. The feces were removed through the opening at the bottom twice daily and at the end of the period any adhering particles were washed out with alcohol.

METHODS OF ANALYSIS.

The foods used in the experiments were analyzed by the official methods given in Bulletin 107 (Revised), also the feces as far as possible, but in the case of the latter, as urine and solids are voided together, the amount of protein undigested could not be found by making the usual total nitrogen determination. In the urine of mammals the main portion of the nitrogen, representing the proteid digested, occurs in the form of urea and very little is present in the form of uric acid, while in birds' urine the reverse condition is true and the larger part of the nitrogen present is in the form of uric acid. Therefore, in order to determine the amount of nitrogen which was present as undigested proteid it was necessary to determine the other forms separately. The ammonia was determined by the official method, namely distillation with MgO, but for uric acid there is no official method. Its estimation presents by far the most serious obstacle encountered in digestion experiments with poultry. On account of the presence of ammonia in the feces moisture was determined by drying several days over sulphuric acid in a partial vacuum.

Method for Determining Uric Acid.

After carefully considering all available methods for determining this acid the one worked out by Doctor Brown and given in Bulletin 56, United States Department of Agriculture, Bureau of Animal Industry, page 39, was given a trial. Our first attempts with this method were not very satisfactory. The filtration, after dissolving in piperidin solution, on paper was very tedious and in some cases impossible to carry through. Also in the case of some of the more highly colored feces so much coloring matter was left in the residue that titration could not be carried out. After a great many trials and many determinations by different modifications, the method which was finally adopted and by which most of the determinations were made is as follows:

Ten grams of the ground and thoroughly mixed feces were weighed into a 250 c. c. beaker and treated with 100 c. c. of 95 per cent alcohol filtered through paper and washed twice with 50 c. c. of alcohol, then washed 3 times with ether and allowed to dry. These treatments removed a greater part of the coloring and fatty matter. The residue when dry was returned to the beaker, 100 c. c. of a .5 per cent solution of HCl added and set in the refrigerator over night. The following morning the material was filtered through paper and washed twice with cold water, returned to the beaker with 100 c. c. of water and enough piperdine or sodium hydrate added to dissolve the uric acid. Piperdine was usually used as the solvent, as it seemed to dissolve the uric acid more quickly than a weak solution of sodium hydrate. A few drops of phenolphthalein were added

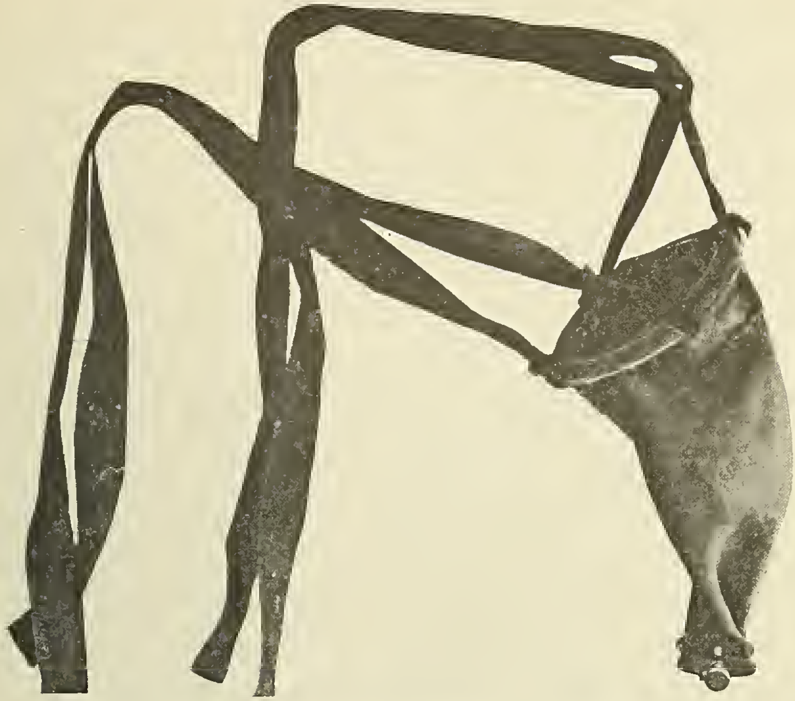

Fig. 235. Collection bag with straps.

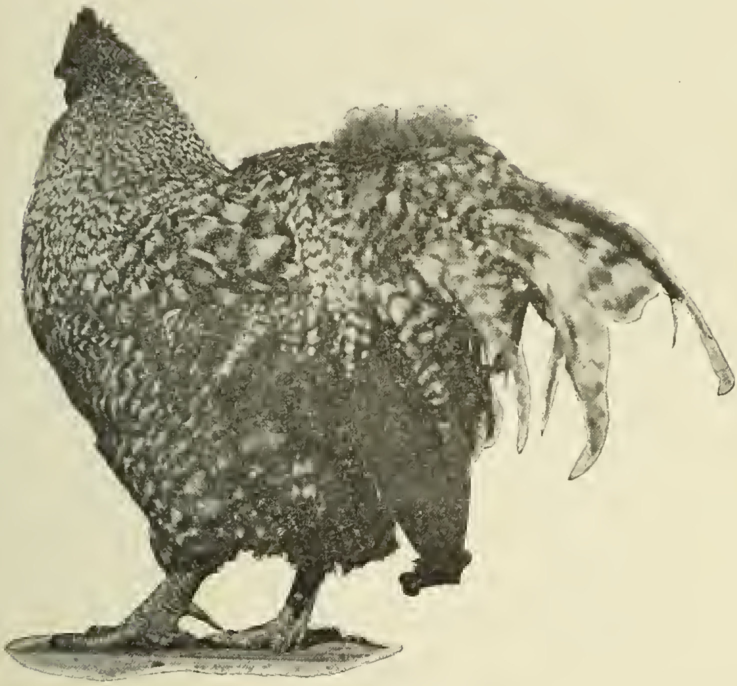

Fig. 236. Collection bag attached.

to the solution in order to determine the amount of alkali necessary to dissolve all the uric acid, also the disappearance of the white particles which settle to the bottom of the beaker indicated complete solution. Usually it required one-half to three-fourths of an hour heating on the steam bath with frequent stirring to effect complete solution. After the white particles had all disappeared and the solution remained alkaline it was passed through a coarse linen filter into a 500 c. c. graduated flask, washed thoroughly with hot water, squeezing out the filter two or three times to facilitate washing, cooled, made up to the mark and thoroughly mixed. This solution was then allowed to settle until the fine particles which passed through the cloth had settled out leaving a clear solution which could be drawn off. It was planned to allow the flasks to settle over night and the solutions were found to be clear the next morning. Fifty c. c. portions, representing 2 grams of the feces, were taken, made acid with HCl, evaporated on steam bath to 25 c. c. and set in the refrigerator for 24 hours. Filtration was then carried out without difficulty through a 597 S. & S. filter paper on a Buckner's porcelain funnel 50 mm. in diameter, under pressure, washed 3 times with cold water, then with absolute alcohol and lastly 2 or 3 times with ether to remove any traces of fat remaining. The uric acid was thus collected on a very small filter paper which was transferred to a beaker, boiled with 35 c. c. of distilled water and titrated with either 1-10 normal piperidine or sodium hydrate. It was found necessary to complete the end reaction with the solution as near the boiling point as possible or concordant results could not be obtained. In all cases 3 portions of 50 c. c. were taken out for the determination. The first titration being made somewhat roughly to find the approximate end point. In carrying out the titration as the end point was being reached the beaker was again put over the flame and brought to the boiling point, then titrated to completion. To test the accuracy of the method pure uric acid was added to feces that contained none. The average of the determinations gave 98 per cent of the acid recovered.

The piperidine and soda solutions were standardized with uric acid which was purified by twice recrystallizing, and found to be practically pure. The writer found that 1-10 normal

NaOH could be used in place of the 1-10 normal piperidine and give practically the same results. Comparisons of several samples of feces were made using the two solutions with the following results:—

	Titration with NaOH	*Titration with Piperidine*
Sample No. 1.	11.5 per cent uric acid	11.6 per cent uric acid
Sample No. 2.	7.31 per cent uric acid	7.35 per cent uric acid
Sample No. 3.	10.85 per cent uric acid	10.80 per cent uric acid
Sample No. 4.	8.97 per cent uric acid	8.91 per cent uric acid
Sample No. 5.	9.98 per cent uric acid	9.92 per cent uric acid
Sample No. 6.	10.14 per cent uric acid	10.15 per cent uric acid
Sample No. 7.	10.15 per cent uric acid	10.18 per cent uric acid

FOODS EXPERIMENTED WITH.

Such feeds were selected as are most commonly used for poultry foods in this country. Probably no other one grain is so universally fed east of the Rocky Mountains as corn in some form or other and there seems to be no other grain so well relished by the birds. In some sections, particularly on the Pacific Coast, wheat largely replaces corn. In other sections oats and buckwheat or India wheat form an important part of the ration. In the mashes, particularly the dry mashes so-called, wheat bran forms an important part, often as much as 50 per cent, consequently this material was included in the test and several dry mash mixtures such as are usually fed.

Beef scraps. Best quality found in the market.
Bran, wheat. The coarses variety from spring wheat.
Corn, whole. No. 2 yellow, picked over and cleaned.
Corn, cracked. From No. 2 yellow, screened.
Corn meal. From No. 2 yellow corn.
Clover, cut. From second crop, just beginning to blossom.
India wheat. Fair quality, picked over and cleaned.
Oats. Best Western clipped oats, carefully picked over.
Oats, rolled. One of the best table varieties.
Wheat, hard. A variety of hard wheat sold as "hen wheat."
Wheat, soft. A seed wheat, rather soft, large, plump grain.
Dry mash mixtures:—

No. 1.	3000 grams bran
	1125 grams corn meal
	1125 grams gluten feed
	600 grams beef scrap.

No. 2.	200 grams bran
	100 grams corn meal
	50 grams linseed meal
	40 grams beef scrap.
No. 3.	200 grams bran
	50 grams corn meal
	50 grams linseed meal
	100 grams gluten feed.

Mixture No. 3 was fed alone in one experiment and in another with about 7 per cent of bone ash to test the effect on digestibility of adding bone ash to a ration consisting of wholly vegetable matter.

CONCLUSIONS.

The results obtained in the experiments here presented indicate that the digestion coefficient of most nutrients for poultry are not materially different from other farm animals. Unlike ruminants, however, they digest very little crude fiber, hence a coarse fodder carrying much of this material is of but little value to them. The nutrients of wheat do not seem to be as well handled as most other concentrated grains, the ether extract showing a particularly low coefficient. Likewise bran, one of the wheat offals, shows low digestibility in organic matter, ether extract and nitrogen free extract. Its bulky and coarse condition has brought it much into favor to feed with more concentrated materials and it often makes as much as 50 per cent of the mixtures used for mashes.

The mixture of equal parts corn meal and fine cut early clover used in the experiments was sufficiently bulky to feed with concentrates, was more digestible and at present prices more economical providing, of course, the poultry man produces his own clover, which he should do. An exclusive diet of wheat had a deranging effect upon the digestive system of the birds.

Our results, like those of Brown and others, show that corn is a most valuable grain for poultry. Its palatibility and high digestibility has brought it into much favor with all poultrymen. It cannot, of course, be fed alone as it is too concentrated a feed and also deficient in protein, but when combined with feeds rich in protein and some bulky material as cut clover, it makes up a most desirable ration.

Oats and India wheat are desirable grains and may be used to some extent to give variety to the ration, but are much more expensive feeds than corn unless one is in a section of the country where they can be bought or produced much more cheaply than at the commercial centers.

The dry mash mixtures Nos. 1 and 2 have about the same digestibility and feeding value. Mixture No. 3 made up wholly of vegetable matter was not so well relished by the birds and gave slightly lower coefficients of digestibility, but the addition of about 7 per cent. of bone ash to the mixture increased the average digestion coefficient obtained with it but the differences were not greater than often occur between different birds on the same ration, so no definite conclusions can be drawn from the results.

SUMMARY.

1. Corn shows a higher digestibility than any other grain tested.
2. Wheat bran shows a low digestibility and at present prices is not an economical feed.
3. A mixture of equal parts early, fine cut clover and corn meal is more digestible and a more economical feed than bran.
4. India wheat compares favorably with oats as a grain for fowls.
5. The ether extract of wheat has a low digestible coefficient.
6. Crude fiber was but very slightly digested and evidently is of but little use in a ration for poultry except to give bulkiness.
7. The mixing of about 7 per cent of bone ash with a ration consisting wholly of vegetable matter gave slightly higher average digestion coefficients than when the mixture was fed without it.

TABLE I.

Composition of Air Dry Foods and Feces.

	Station number.	Water.	Ash.	Protein.	Ammonia.	Uric acid.	Crude fiber.	Nitrogen free extract.	Ether extract.	Calories per gram.
Experiment with Bran, Wheat	4447	8.22	6.67	15.25	–	–	8.42	57.56	3.88	4.090
Feces Capon, 108	4448	4.47	10.81	7.75	.47	6.24	12.68	53.35	4.23	3,938
Feces Cock. 152	4449	4.62	10.91	6.69	.56	6.98	12.23	54.00	4.01	3,893
Feces Capon, 168	4450	4.69	10.63	8.12	.68	6.20	12.37	53.08	4.23	3,923
Experiment with Whole Corn	4427	5.57	1.35	9.35	–	–	1.59	77.51	4.60	4.099
Feces Hen, 717.	4433	5.45	24.59	13.94	1.44	9.80	10.38	31.27	2.82	3,165
Experiment with Cracked Corn	4430	10.36	1.27	9.50	–	–	2.14	72.65	4.08	3,947
Feces Hen. 6	4438	6.02	14.48	11.69	1.34	11.37	10.92	41.79	2.39	3.506
Feces Hen. 7	4439	9.47	14.59	12.19	2.39	8.81	12.65	35.68	2.36	3,547
Experiment with Corn Meal	4457	7.27	1.77	9.00	–	–	2.25	75.89	3.82	4,140
Feces Capon, 168	4461	4.65	7.82	12.25	1.19	8.53	12.59	50.80	2.17	3,853
Feces Cock, 84	4462	4.24	7.87	10.55	.86	11.87	12.19	50.03	2.39	3,831
Experiment with Clover and Meal, 4457	4456	5.25	10.32	20.23	–	–	22.56	38.92	2.62	4,152
Feces Capon, 108	4458	5.16	14.44	8.25	.22	6.30	21.50	42.06	2.07	3,706
Feces, 38	4459	4.96	13.76	8.69	.26	6.20	22.09	41.95	2.09	3,725
Feces, 168	4560	4.86	13.41	6.81	.26	6.47	21.33	44.82	2.04	3,731
Experiment with Meal (4457) and Beef Scrap	4463	4.84	23.02	48.69	–	–	–	–	18.71	4,618
Feces Capon, 108	4464	4.74	21.76	12.25	1.04	17.05	7.50	32.97	2.69	3.170
Feces Cock, 38	4465	3.47	19.83	9.56	1.35	20.30	7.76	35.69	2.04	3,194
Experiment with India Wheat	4432	8.31	4.17	9.38	–	–	13.42	62.33	2.39	3,948
Feces Hen, 10	4441	7.62	16.76	6.63	.95	5.05	30.76	31.01	1.22	3,292
Feces Hen, 12	4442	6.77	21.36	6.13	.78	4.12	30.27	29.55	1.02	3,521
Feces Hen, 13	4443	6.81	12.31	9.38	1.09	5.62	32.58	31.05	1.15	3,793
Experiment with Corn Meal, 7 parts and	4466	5.43	1.33	9.50	–	–	1.78	78.04	3.90	4.090
Beef Scrap, 1 part	4467	7.19	26.63	44.94	–	–	–	–	17.19	4.158
Feces Capon, 832	4468	5.27	18.05	14.00	1.61	16 20	9.29	32.55	3.03	3,110
Feces Capon, 835	4469	3.64	20.20	14.69	1.83	15.81	8.53	32.78	2.52	3,141
Feces Capon, 161	4471	5.17	16.21	10.00	1.68	18.30	10.21	34.11	4.42	3,255

Table 1.—Concluded.

	Station number.	Water.	Ash.	Protein.	Ammonia.	Uric acid.	Crude fiber.	Nitrogen free extract.	Ether Extract.	Calories per gram.
Feces Capon. 162	4472	5.26	23.48	11.31	1.71	14.48	10.58	30.20	2.98	2.943
Experiment with Oats Whole	4451	7.90	3.76	12.95	-	-	9.10	62.06	4.23	4.223
Feces Cock, 48	4452	4.02	17.52	6.06	.36	6.66	19.22	44.96	1.20	3.609
Feces Cock. 84	4453	4.27	15.78	6.06	.36	5.83	19.81	46.79	1.10	3.673
Feces Capon. 36	4454	4.61	13.08	7.62	.40	4.65	19.63	48.78	1.23	3.793
Feces Cock 38	4455	4.45	10.96	4.56	.45	6.39	20.45	51.49	1.30	3.906
Mixture No. 1	-	8.78	7.26	19.19	-	-	6.72	52.46	5.59	4.110
Feces Capon, 434	4478	5.71	12.50	6.00	.75	10.83	13.50	48.18	2.53	3.605
Feces Capon 832	4479	10.75	11.97	7.06	.68	8.95	11.37	46.59	2.63	3.481
Feces Capon, 835	4480	9.06	13.25	7.25	.71	9.95	12.21	44.73	2.84	3.473
Feces Capon, 162	4481	4.68	18.28	6.69	.67	10.14	13.03	44.77	1.74	3.378
Feces Capon, 163	4482	4.44	18.74	5.31	.52	10.00	13.09	45.93	1.97	3.428
Mixture No. 2	-	8.83	7.57	19.06	-	-	6.58	52.47	5.48	4.056
Feces Capon, 163	4483	4.19	14.10	8.31	.83	10.14	12.38	47.53	2.72	3.632
Feces Capon, Blank	4484	4.47	13.18	8.06	.96	9.60	12.98	48.91	1.84	3.663
Feces Capon, 162	4485	6.46	17.73	8.50	.91	9.90	11.97	42.42	2.14	3.437
Mixture No. 3	-	9.59	6.00	18.41	-	-	8.29	53.60	4.00	4.229
Feces Capon, 163	4497	4.37	16.55	7.44	.68	7.83	12.73	48.86	1.54	3.340
Feces Capon, 832	4498	4.65	15.37	5.86	.68	7.90	13.25	50.61	1.68	3.441
Feces Capon. 835	4499	4.42	15.92	6.28	.46	8.39	13.61	48.57	2.37	3.476
Mixture No. 3. with bone ash	-	-	-	-	-	-	-	-	-	-
Feces Capon. B	4501	4.64	22.18	5.06	.42	8.01	11.78	45.67	2.24	3.146
Feces Capon 1	4502	4.40	21.27	5.62	.57	7.60	12.02	47.13	1.39	3.181
Feces Capon, 434	4503	5.73	24.12	6.19	.42	8.29	11.18	42.12	1.95	3.043

TABLE 2.

Weight of Food and Feces and Other Data Relating to the Experiments.

Material fed and Station number.	Kind of bird.	Bird's number.	Station number feces.	Weight of air dry food eaten during collection period.	Weight of air dry feces excreted during collection period.	Weight of bird.	Weight lost during collection period.	Duration of experiment	
								Preliminary period.	Collection period.
				grams	grams				
Bran, wheat, (4447)............	Capon	108	4448	700	404	–	–	7	7
Bran. wheat, (4447)......	Cock .	152	4449	800	471	–	–	6	8
Bran, wheat, (4447)............	Capon	168	4450	800	469	–	–	6	8
Whole corn, (4427).............	Hen ..	717	4433	420	89.6	2246	71	7	7
Corn, cracked, (4430)..........	Hen ..	6	4438	420	96.0	–	–	7	7
Corn, cracked, (4430)..........	Hen ..	7	4439	420	90.0	–	–	7	7
Corn meal, (4457)..............	Capon	168	4461	600	123.5	–	–	7	6
Corn meal, (4457)..............	Cock .	84	4462	480	94.0	–	–	7	6
Meal, (4457) and...............	Capon	108	4458	480	253.8	–	–	7	6
Clover, (4456,) equal. parts....	Cock .	38	4459	600	313.0	–	–	7	6
	Capon	168	4460	600	295.0	–	–	7	6
Meal, (4457) and................	Capon	108	4464	550	143	–	–		
Beef scraps, (4463,) equal parts	Cock .	38	4465	600	164	–	–	7	6
India wheat, (4432)............	Hen ..	10	4441	252	105	–	–	7	6
	Hen ..	12	4442	350	151.5	–	–	7	7
	Hen ..	13	4443	352.8	142	–	–	7	7
Corn meal, (4466,) 7 parts.....	Capon	832	4468	475	95.4	3256	24	6	6
and beef scrap, (4467) 1 part..	Capon	835	4469	480	132.6	3064	43	6	6
	Capon	908	4470	535	47.6	2330	gained 50	–	7
	Capon	161	4471	450	75.4	2605	50	7	6
	Capon	162	4472	450	70.0	4050	gained 5	7	6
Oats, whole, (4451)	Cock .	48	4452	300	14.0	–	–	6	3
Oats, whole, (4451)	Cock .	84	4453	480	219	–	–	6	6
Oats, whole, (4451)	Capon	36	4454	480	225.5	–	–	7	6
Oats, whole, (4451)	Cock .	38	4455	480	221.0	–	–	7	6
Oats, rolled, (4486)............	Capon	832	4487	250	49.8	3355	35	6	5

Table 2.—Concluded.

Material fed and Station number.	Kind of bird.	Bird's number.	Station number feces.	Weight of air dry food eaten during collection period.	Weight of air dry feces excreted during collection period.	Weight of bird.	Weight lost during collection period.	Duration of experiment: Preliminary period.	Duration of experiment: Collection period.
Oats, rolled. (4486	Capon	1	4490	255	93.8	4340	130	6	5
And mixture No. 2	Capon	2	4491	138	53.6	-	-	6	5
	Capon	434	4492	297	99.6	3190	50	6	5
Wheat, 4428	Hen	1	4434	120	119.0	2300	90	7	7
Mixture No. 1	Capon	434	4478	375	229.2	3250	10	7	6
Bran (4473) 3000 grams	Capon	832	4479	425	272.6	3210	gained 15	7	5
Corn meal (4474) 1125 grams	Capon	835	4480	450	291.0	3135	gained 30	7	7
Gluten meal (4476) 1125 grams	Capon	162	4481	375	204.0	4450	65	7	7
Beef scrap (4475) 600 grams	Capon	163	4482	375	214.0	3324	35	7	7
Mixture No. 2									
Bran (4473) 200 grams	Capon	163	4483	375	218.4	3150	75	7	5
Corn meal (4474) 100 grams	Capon	-	4484	375	211.2	4465	65	7	5
Linseed meal (4477) 50. grams	Capon	162	4485	375	200.0	[illegible]	55	7	5
Beef scrap (4475) 40 grams									
Mixture No. 3									
Bran (4493) 200. grams	Capon	163	4497	200	148	3365	140	7	5
Corn meal (4494) 50 grams	Capon	832	4498	400	254	3130	25	7	5
Linseed meal (4496) 50 grams	Capon	835	4499	400	260.8	2900	25	7	5
Gluten feed (4495) 100 grams									
Mixture No. 3	Capon	-	4501	350	239	2447	55	7	5
With about 7%	Capon	1	4502	350	244.2	3875	45	7	5
Bone ash added	Capon	434	4503	290	207.8	2890	75	7	5
Wheat, No. (4429)	Hen	3	4435	360	68.5	-	-	7	5
	Hen	4	4436	300	86.0	-	-	7	5
	Hen	5	4437	360	101.7	-	-	7	6
Wheat, (4444)	Cock	38	4445	600	122.5	-	-	7	6
	Cock	37	4446	600	120.0	-	-	7	5

TABLE 3.

Coefficients Obtained With Each Bird.

	Bird Employed.	Feces Number.	Organic Matter.	Crude Protein.	Crude Fiber.	Nitrogen Free Extract.	Ether Extract.	Calories Per cent.
Wheat bran (4447) ……………	Capon 108	4448	47.1	72.3	13.1	46.2	37.06	46.8
	Cock 152	4449	46.8	74.2	13.6	45.7	38.4	46.8
	Capon 168	4450	46.3	68.8	13.9	46.0	35.4	46.2
Whole corn (4427) ……………	Hen 717	4433	86.62	68.31	–	91.6	87.0	84.9
Cracked corn (4430) …………	Hen 6	4438	82.72	71.85	–	86.85	86.65	81.5
	Hen 7	4439	83.77	72.5	–	89.46	87.58	82.1
Corn meal (4457) ………………	Capon 168	4461	82.4	72.00	–	84.0	88.3	82.0
	Cock 84	4462	83.8	77.1	–	87.9	86.9	83.4
Clover (4456) and corn meal….	Capon 108	4458	55.7	69.4	8.5	61.3	66.0	55.0
(4457) in equal parts…………	Cock 38	4459	55.7	69.0	7.2	61.9	66.1	55.3
	Capon 168	4460	57.9	77.1	15.5	61.7	68.8	57.9
Meal (4457) and beef scrap……	Capon 108	4464	82.5	89.0	–	77.3	93.8	79.2
(4463) equal parts………………	Cock 38	4465	81.6	90.9	–	77.4	95.1	83.7
India wheat (4432)……………	Hen 10	4441	66.9	74.9	5.	79.3	78.8	66.4
	Hen 12	4442	75.9	79.5	29.1	85.5	86.6	62.7
	Hen 13	4443	75.1	70.6	28.6	85.4	85.9	62.9
7 parts corn meal (4466) and….	Capon 832	4468	86.8	79.9	–	90.4	10.0	86.2
Beef scrap (4467) 1 part………	Capon 835	4469	81.6	70.9	–	86.8	87.5	81.9
	Capon 908	4470	94.1	85.7	–	96.3	93.4	–
	Capon 161	4471	89.0	87.8	–	91.6	86.7	88.6
	Capon 162	4472	90.5	87.4	–	93.2	91.7	90.3
Oats, whole (4451)……………	Cock 48	4452	62.1	78.1	1.5	66.0	82.2	62.2
	Cock 84	4453	61.9	78.5	–	65.6	89.3	62.1
	Capon 36	4454	58.9	72.3	1.9	63.1	84.5	59.2
	Cock 38	4455	59.4	83.7	–	61.8	87.0	59.1
Oats, rolled (4486) ……………	Capon 832	4487	84.00	81.0	–	84.8	86.2	82.7

Table 3.—Concluded.

	Birds Employed.	Feces Number.	Organic Matter.	Crude Protein.	Crude Fiber.	Nitrogen Free Extract.	Ether Extract.	Calories Per cent.
Oats, rolled (4486) when fed......	Capon 1	4490	79.3	77.9	–	86.8	101.6	81.8
With equal parts..................	Capon 2	4491	95.4	70.9	–	102.8	91.8	71.6
Mixture No. 2..	Capon 434	4492	98.6	90.5	–	102.7	89.0	74.4
Wheat hard (4427)...............	Hen 1	4434	81.82	71 3	–	80.8	56.9	80.1
Wheat soft (4429).................	Hen 3	4435	85.36	71.66	17.14	90.3	60.2	82.2
	Hen 4	4436	82.22	57.02	–	89.6	68.6	79.2
	Hen 5	4437	80.55	69.82	–	87.0	50.6	76.1
Wheat soft (4444).................	Cock 38	4445	80.22	77.33	–	88.1	45.1	80.3
	Cock 87	4446	80.7	78.7	–	87.7	47.7	81.0
Mixture No. 1....................	Capon 434	4478	48.8	80.9	–	43.3	73.8	50.8
	Capon 832	4479	48.3	76.4	–	65.3	69.9	49.6
	Capon 835	4480	48.4	75.6	–	44.9	67.1	55.2
	Capon 162	4481	57.2	81.0	–	53.6	83.0	59.0
	Capon 163	4482	54.9	84.0	–	50.0	79.9	56.2
Mixture No. 2....................	Capon 163	4483	50.7	75.0	–	47.3	73.2	51.8
	Capon Blank	4484	51.7	76.2	–	47.5	81.1	52.8
	Capon 162	4485	51.8	74.6	–	45.2	81.1	58.4
Mixture No. 3....................	Capon 163	4497	35.4	70.1	–	32.6	71.5	30.2
	Capon 832	4498	46.2	79.8	–	39.9	73.3	50.5
	Capon 835	4499	45.2	77.7	–	40.9	61.3	47.8
Mixture No 3.....................	Capon Blank	4501	47.6	81.5	–	41.9	66.6	50.4
With bone ash....................	Capon 1	4502	45.3	78.7	–	38.7	75.7	49.4
	Capon 434	4503	47.8	75.8	–	43.7	64.1	50.0

In Table 4 below is given the average of all the digestion coefficients obtained on the different grains and mixtures experimented with. Comparing these figures with results obtained with other animals, it is interesting to note that they agree quite closely with those obtained with swine, as was noted by Lehmann. Also that coefficients of digestibility found for corn and wheat agree quite well with those obtained by Lehmann and Paraschutschuk who made use of an artificial anus to separate the urine from the solid feces.

TABLE 4.

Average of the Digestion Coefficients Obtained for the Foods.

	Number of experiments.	Organic Matter.	Protein.	Crude Fiber.	Nitrogen free extract.	Ether extract.	Calories.
Wheat bran (coarse)	3	46.7	71.7	13.5	46.0	37.0	46.6
Corn whole	1	86.6	68.3	–	91.6	87.0	84.9
Corn cracked	2	83.3	72.2	–	88.1	87.1	81.8
Corn meal	2	83.1	74.6	–	86.0	87.6	82.7
Corn meal and clover equal parts	3	56.4	71.5	10.4	61.6	66.9	56.1
Clover, calculated	3	27.7	70.6	10.4	14.3	35.5	–
Corn meal and beef scrap equal parts	2	82.1	90.0	–	75.8	95.0	81.5
Beef scrap, calculated	2	80.2	92.6	–	–	95.6	–
Corn meal (7 parts) beef scrap (1 part)	4	87.0	81.5	–	90.5	91.5	–
India wheat	3	72.7	75.0	20.9	83.4	83.8	64.0
Oats whole	4	60.6	78.2	–	64.1	85.6	60.6
Oats rolled	4	89.3	80.1	–	94.3	92.2	82.7
Wheat hard	1	81.8	71.3	–	80.8	56.9	80.1
Wheat soft	5	81.8	74.4	–	88.5	54.4	79.7
Mixture No. 1	5	51.3	78.6	–	51.4	74.8	54.1
Mixture No. 2	3	51.4	78.6	–	46.7	78.5	54.3
Mixture No. 3	3	42.3	75.8	–	37.8	68.7	42.6
Mixture No. 3 and bone ash	3	46.9	79.0	–	45.3	68.8	49.9

In Table 5 below are given the average coefficients obtained in all published digestion experiments with poultry known to the writer. The extremely low results given by Fields & Ford for protein in corn and peas are omitted from the averages. Aside from the results obtained at this Station figures were taken from the following authors and sources: Fields & Ford, Bulletin 46, Agricultural Experiment Station, Oklahoma. Brown, Bulletin 56, Bureau of Animal Industry, U. S. Department of Agriculture. Paraschutschuk. Journ. f. Landwirtsch. Berlin 50 J. Heft. 1, 9. Mai p. 15-32. 1902. Knieriem, Grost, Landwirtsch. Jahrb. Berlin. Bd. 29, Heft 3, 22. Juni p. 52-, 1900. Voltz, Lehmann, Kalugin. Landwirtschaftlighe Jahrbucher. Bd. 38, p. 553, 1909.

TABLE 5.

Average of Digestion Coefficients Obtained with Poultry to Date.

	Number of experiments.	Organic Matter.	Crude Protein.	Nitrogen free Extract.	Ether Extract.
Bran, wheat	3	46.70	71.70	46.00	37.00
Beef scrap	2	80.25	92.60	–	95.00
Beef, (lean meat)	2	87.65	90.20	–	86.30
Barley	3	77.17	77.32	85.09	67.86
Buck wheat	2	69.38	59.40	86.99	89.22
Corn, whole	16	86.87	81.55	91.32	88.11
Corn, cracked	2	83.30	72.20	88.10	87.60
Corn, meal	2	83.10	74.60	86.00	87.60
Clover	3	27.70	70.60	14.30	35.50
India wheat	3	72.70	75.00	83.40	83.80
Millet	2	–	62.40	98.39	85.71
Oats	13	62.69	71.31	90.10	87.89
Peas	8	77.07	87.00	84.80	80.21
Wheat	10	82.26	75.05	87.04	53.00
Rye	2	79.20	66.90	86.70	22.60
Potatoes	6	78.33	46.94	84.46	–